REMARKS

Claims 1-28 remain in this application. Claims 7-9 and 15 have been amended to depend from Claims 1 and 14, as originally intended. By these amendments, no new matter has been added.

The Examiner rejected Claims 7-9 and 15 under 35 U.S.C. § 112, second paragraph, as being indefinite. These rejections are respectfully traversed. Applicant thanks the Examiner for suggesting the correction of these claims. The rejected claims have been amended to provide sufficient antecedent basis for the limitations noted by the Examiner, and are believed to be sufficiently definite. These rejections should therefore be withdrawn.

Before addressing the remaining rejections in detail, it may be helpful to generally compare and contrast the present invention with the primary prior art reference applied in the Examiner's rejections under 35 U.S.C. §§ 102 and 103. Like Debevec, the present invention concerns the rendering and compositing of computer-generated digital objects with photographic images of real objects. However, the present invention provides a method that is different than that disclosed by Debevec in several respects. As such, the present invention is believed to provide solutions to problems encountered during the production of motion pictures, which surpass the method of Debevec.

Debevec, for example, fails to disclose or suggest a method for accurately rendering a digital object that is to be placed in motion against a photographed background of a movie set. Debevec fails to even mention this problem. Even if the method of Debevec were to be applied on a frame-by-frame basis, for example, by repeating the method for each frame or for selected key frames (neither of which is disclosed by Debevec), such an approach would be too tedious and expensive for movie production. For example, sampling might be required for hundreds of key frames just to accurately render a relatively short scene, and interpolation would have to be

performed between key frames.

In contrast, the present invention provides a different approach that is more practical and effective in a movie production environment. A defined physical space comprising a movie set is sampled at different points to provide image datasets, each of which are used to define a panoramic map of lighting color and intensity. Relatively few sampling points should be needed for most scenes, such as, for example, on the order of approximately ten samples. From this limited number of data sets, any number of moving objects can be rendered with sufficient accuracy much more quickly than would otherwise be possible.

Another important difference resides in the modeling of ambient light. Debevec teaches creating a three-dimensional (3D) model of an ambient environment. (Col. 5:5-9; 8:10-11.) In contrast, the present invention uses two-dimensional (2D) panoramic maps, and does not require construction of a 3D model. (Claim 1, l.6; p.14, l.21 – p.15, l.15.) This is a distinctly different approach.

Still further differences exist. Debevec, for example, teaches dividing the 3D model into near objects, for which both reflectance and radiance are determined, and distant objects, for which radiance only is determined. (Col. 6:21 – 7:50.) In both cases, the modeled radiant and reflective surfaces represent 3D objects. In contrast, in an embodiment of the invention, 2D panoramic maps are processed to define key lights and directional fill lights that approximate the light environment. (Claim 11; p. 15, l.19 – p.16, l.6 and p.17, l.26 – p.18, l. 15.) While key lights may be modeled as traditional 3D light sources, the modeled fill lights may be deliberately configured as lacking certain 3D qualities, such as distance from the illuminated object. (P. 19, l. 7-11.) More to the point, it should be clear that creating an array of modeled key and fill lights is a distinctly different approach from modeling radiant and reflective 3D surfaces, whether near or far, as disclosed by Debevec.

Yet other difference should be apparent. Debevec discloses partitioning objects in a modeled 3D light environment into near and distant groups, for the purpose of

reducing reflectance computations. As Debevec acknowledges, purely geometrical factors will often not produce realistic results, requiring the exercise of judgment as to which objects in a scene should be considered nearby or distant. (Col. 7:2-22.) In contrast, the present invention is not concerned with modeling reflectance from the modeled object, and uses a very different modeling approach. In an embodiment of the invention, the modeled light may be segmented based on a purely geometric relationship between the modeled object and a global light primitive, e.g., a solid angle. (Claim 13; Figs. 7-8; p.25, l.1-10.) Again, these are different approaches that yield different results.

In summary, the invention provides numerous novel method steps that are neither disclosed nor suggested by Debevec. It is further respectfully submitted that the present invention provides rendering methods that are more suitable for rendering certain objects in production environments, where a method such as disclosed by Debevec would be too computationally complex and slow. The development and application of rendering tools that both produce realistic results and are computationally efficient would have been neither easy nor obvious to one of ordinary skill at the time the invention was made, whether in view of Debevec or other prior art.

The pending rejections will now be addressed in detail.

The Examiner rejected Claims 1-5, 10-19 and 23-28 under 35 U.S.C. § 102(e) as anticipated by Debevec. These rejections are respectfully traversed.

As to Claims 1 and 17, Debevec discloses only the use of a *single* radiance measurement (e.g., using a single reflecting ball placed at a particular location in the scene.) Thus, Debevec fails to disclose or suggest modeling a dynamic lighting model from a plurality of panoramic maps, as defined by Claims 1 and 17. In contrast, the invention defines creation of a single model from a plurality of panoramic maps each associated with substantially different locations or lighting conditions. Panoramic maps are developed for different locations in the set or at different times having different lighting conditions, as defined in the first step of Claim 1. These separate maps are

used in a combined fashion in a dynamic lighting model, that may be applied to more quickly render objects moving through the set or exposed to changing lighting conditions. Debevec is unconcerned with solving these problems, and fails to disclose or suggest integrating radiance data from multiple image sets taken at different times or under different lighting conditions into a single integrated model of any kind.

Furthermore, Debevec fails to disclose or to suggest reading a plurality of multiple-exposure image datasets *each corresponding to a substantially different location or a substantially different lighting condition* within a limited physical space, developing a plurality of panoramic maps each derived from images in a corresponding one of the image sets, and rendering at least *a single frame* of a video or motion picture sequence using a model developed from the plurality of maps. At most, Debevec discloses using data from two images of the same ball at the same location to render a frame. (Col. 8:41-44.) All of the image-gathering methods disclosed by Debevec (e.g., col. 5:56 – 6:4) are designed to gather data at a *single* location under substantially the same lighting conditions.

Debevec fails to disclose how to render different frames of a video sequence at all. It should be apparent, however, that a multiple-exposure image sequence as disclosed by Debevec is used to define a particular static lighting condition at a particular location, such as would be useful to render a single frame or photograph. Debevec fails to disclose collecting image sequences for substantially different locations or lighting conditions, and using such sequences to render a single frame. Nor would it have been obvious to do so. Instead, one of ordinary skill would have applied the method of Debevec on a frame-by-frame basis, if at all.

With respect to independent Claim 16, and dependent Claims 11, 15, and 24, Debevec fails to disclose or suggest modeling a lighting model comprised of key lights and fill lights. Instead, Debevec expressly teaches away from the modeling of light sources at col. 2:32-35. Debevec also teaches away from this approach by partitioning a 3D model into distant and local scenes. (Col. 6:21-25.) The basis for this partitioning,

Debevec teaches, is whether the scene is close enough to receive noticeable light *from* the rendered digital object. (Col. 6:40-47.) In contrast, key and fill lights according to the invention are distinguished on the basis of light intensity directed *towards* the object to be rendered. (See, e.g., p. 16, l.11-13.) Also, both key lights and fill lights may comprise modeled directional lights. In contrast, the distant and local scenes in the 3D model of Debevec do not comprise directional lights, but rather radiant surfaces in a 3D model.

Failing to disclose all the limitations of Claims 1, 16 and 17, Debevec cannot anticipate them. Claims 2-5, 10-15, 18-19 and 23-28 are also allowable, at least as depending from an allowable base claim. Further deficiencies of Debevec are noted below with respect to certain of the dependent claims.

As to Claims 2 and 3, Debevec fails to disclose reading or otherwise using image datasets corresponding to substantially different locations, or substantially different lighting conditions at different times within the defined physical space, and modeling a lighting model accordingly. These deficiencies have been further discussed above in connection with Claims 1 and 17.

As to Claim 5, Debevec fails to disclose any model in which lighting varies as a function of time. In raising this rejection, the Examiner cited 2:18-29, but this portion of Debevec does not disclose the limitations of Claim 5 at all. At most, Debevec merely suggests that rendering methods may be applied for visual effects, without specifying motion pictures at all. The examiner argued that these limitations would be inherent in rendering a moving actor, but this argument must fail. Even if Debevec's method were to be applied to a motion picture, no time-dependent lighting model would inherently be created. The method of Debevec may merely be applied independently to each frame, without creating any time-dependent model for rendering multiple frames.

As to Claims 13 and 26 Debevec fails to disclose subdividing the modeled light-emitting surface into surface regions based on a geometric relationship between a digital object to be rendered and the modeled light-emitting surface, wherein the surface

regions each correspond to a projection of a defined maximum size on a surface enclosing the digital object. Instead, Debevec discloses partitioning objects in a modeled 3D light environment into near and distant groups, for the purpose of reducing reflectance computations. As also explained above, Debevec discloses that the basis for this partitioning is whether the scene is close enough to receive noticeable light from the rendered digital object. (Col. 6:40-47.) No reference is made to determining a maximum solid angle, e.g. by using a projection surface. To the contrary, Debevec teaches away from the invention, by teaching that purely geometrical factors will often not produce realistic results, requiring the exercise of judgment as to which objects in a scene should be considered nearby or distant. (Col. 7:2-22.)

As to Claims 14 and 27, Debevec does not disclose or suggest interpolating a panorama from a plurality of panoramic maps. Although the Examiner has called out col. 7:57-65 of Debevec as disclosing these limitations, Applicant respectfully disagrees. Debevec actually teaches away from the invention at col. 7:57-65, by disclosing that a distant part of the scene may be rendered correctly "if it is possible to *directly acquire* radiance maps of the scene from the desired viewpoints" (emphasis added.) In other words, Debevec teaches direct measurement for rendering from different viewpoints, *not* interpolation between data.

In view of the foregoing, Claims 1-5, 10-19 and 23-28 are not anticipated by Debevec. These rejections should therefore be withdrawn.

The Examiner rejected Claims 6-9 and 20-22 under 35 U.S.C. § 103(a) as unpatentable in view of Debevec and Reiman. These rejections are respectfully traversed. Claims 6-9 and 20-22 are allowable, at least as depending from allowable base claims, and these rejections should therefore be withdrawn.

In view of the foregoing, the Applicant respectfully submits that Claims 1-28 are in condition for allowance. Reconsideration and withdrawal of the rejections is respectfully requested, and a timely Notice of Allowability is solicited.

To the extent it would be helpful to placing this application in condition for allowance, the Applicant encourages the Examiner to contact the undersigned counsel and conduct a telephonic interview.

While the Applicant believes that no fees are due in connection with the filing of this paper, the Commissioner is authorized to charge any shortage in the fees, including extension of time fees, to Deposit Account No. 50-0639.

Respectfully submitted,

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